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MULTINATIONAL ACTIVITIES OF MAJOR U.S. AUTOMOTIVE PRODUCERS

ume IV -- A Preliminary Evaluation of Technology Innovation and Transfer

Robert C. Ronstadt
William Casey
J.P. Jeannet
John Marthinsen
Robert Whorf

Robert C. Ronstadt Associates, Inc.
46 Glen Street
Dover MA 02030

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FINAL REPORT

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16. Abstract

The multinational activities of General Motors, Ford, Chrysler, and American Motors are documented and analyzed. The study consists of this and four other volumes. Volume I is a summary of the four main volumes. Volume II contains a compilation of data related to multinational operations; specifically it addresses research, development, engineering, production, marketing, and sales activities performed abroad. In Volume III, the research, development, and engineering activities abroad are analyzed. Volume V examines the diffusion of production and sales operations abroad; the timing and location of these investments are shown consistent with the Product Life Cycle Theory of International Trade and Investment.

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
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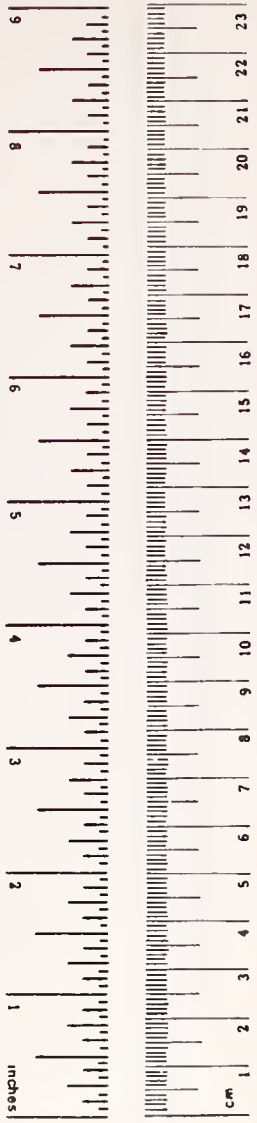

Approximate Conversions from Metric Measures

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mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
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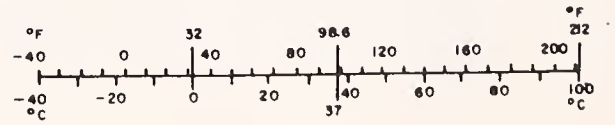

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1. INTRODUCTION

While the major focus of the present study, as reflected in Volume II, III, and V, has been upon the overseas activities of the four U.S. automobile manufacturers, a supplementary concern has been to develop insights into the flows or transfers of technology between each U.S. parent corporation and its subsidiaries and affiliates overseas. Volume IV presents some observations and a preliminary assessment of these technology flows. The examination is far from comprehensive and only peripherally considers the issues of technology transfers between a U.S. manufacturer and independent foreign automobile manufacturers or other independent firms.

Our first task is to define what constitutes a technology transfer. For purposes of the present discussion, we propose a relatively restrictive definition and hold that a technology transfer is only effected (or completed) when a technique, idea or process developed within one organizational unit has been incorporated in the production of products offered for sale by another organizational unit. Under this definition, we exclude from consideration cases where a product manufactured in one country is imported and marketed in another country, e.g., GM's marketing in the U.S. of vehicles designed and produced by Isuzu in Japan or Ford's importing and selling its German made Capri, do not constitute technology transfers to the U.S. company. Similarly, we exclude cases where one unit acquires or has the right to information, products, or processes developed by another unit but has not yet incorporated them into its own products or processes. Such situations clearly represent potential technology

transfers. Included in this class of situations are formal agreements or licenses providing for the use of certain technology but which have not yet resulted (and may not result) in marketable products. Thus, we do not count, for example, Ford's acquisition of rights to N.V. Philip's Stirling engine technology (although Ford now "has" the technology) or G.M.'s acquisition of rights to the Wankel engine as completed technology transfers.

Some writers may well hold that our distinction in this case is too restrictive, since in a legal sense certain property rights have been transfered in exchange for economic or other considerations. However, the question of whether such third party arrangements should be counted is not crucial for our purpose of discussing technology transfers between a U.S. manufacturer and its overseas subsidiaries. And in ordinary usage, the acquisition of a foreign automotive manufacturer by a U.S. company, while clearly representing a transfer of property to the U.S. concern does not itself represent a transfer of technology to the United States. A transfer of technology occurs only after some product or process developed by one concern is utilized in the production of the other. Also, the position taken with regard to technology transfers is consistent with the usual definition of innovation, in that an innovation is not said to occur until some new idea, product or process has resulted in the marketing of a product or service.

However, a gray area remains that is not easily resolved. Transfers of technology (and innovations) can occur or be initiated at any stage in the entire process from initial idea generation, through research, advanced development, prototype development, engineering, testing, manufacturing

development and tooling on to final product marketing. The problem arises then of accounting or crediting a transfer in the case where an innovation is started in one organizational unit but completed in another or where a joint development effort exists that results in the production in one country of work that is in process or draws upon the knowledge and skills resident in another country. While the problem may largely be one of academic interest, it requires giving due credit for the relative contribution of the several national actors in a technological innovation and for identifying transnational flows of technology.

The present volume is organized as follows:

Section 2 presents a number of general observations about the nature and form of intra-corporate automotive technology transfers.

Section 3 then provides a preliminary and incomplete account of technology transfers for each of the U.S. automobile manufacturers.

Section 4 offers some anticipations concerning future trends.

2. INTRA-CORPORATE AUTOMOTIVE TECHNOLOGY TRANSFERS

It is important to recognize that there are both formal and informal transfers of technology. Formal transfers generally involve the execution of a legal instrument, license, or other agreement granting the right to use the technological development(s) of one company by another in exchange for economic or other considerations of value. On the other hand, informal transfers do not involve such legal instruments but represent the flow of knowledge and product/process developments from one organization to another.

The latter class of transfers may or may not involve explicit consent, and in some cases may represent an infringement of one party's legal rights to the technology at issue. Typically transfers, whether completed or potential, between say a U.S. manufacturer and other independent organizations or affiliated companies tend to be formal; whereas, transfers within the corporate family, i.e. between the parent and subsidiary companies, tend to be informal. The very informality of intra-corporate transfers renders their accounting difficult and imprecise. Often such transfers are not recognized as having taken place or as significant events.

The general picture that emerges has two major aspects.

The first aspect is one of the general and widespread diffusion of technology. New developments, wherever

they occur, gradually (and sometimes rapidly)spread throughout the industry. Significant new ideas can appear anywhere but generally appear roughly in proportion to the magnitude of the investment of resources - human and financial.

The second aspect of the picture is what may be characterized as "technological opportunism". There does not appear at present to be any overall scheme or plan for the development, specialization or diffusion of technology. Attention goes to where the problems are. Currently, and for many years to come, the major concern is and will be with fuel economy and energy supply and cost considerations. The fact that for a considerable period the rest of the world has had to contend with higher energy costs and less abundant fuel has resulted in greater attention to such matters and the consequent infusion of relevant technology into the U.S. marketplace. When respondents were asked to identify significant technology transfers to the U.S., the items mentioned were virtually all fuel-economy related, a circumstance that probably reflects both the current focus of attention and (to a lesser degree) a change in the flow of technology. Earlier innovations tend to be forgotten or merely taken for granted. The principal ingredient of opportunism, however, is reflected in the circumstance that products developed and justified to meet the needs of one market may be found later to have relevance for other national or regional markets and are subsequently included within the other markets' product and production bases.

While the intra-corporate technology transfers are informal in a legal sense, they are not haphazard or unorganized. Among the mechanisms employed the following may be noted:

The preparation and periodic updating of engineering and technology want lists. Project proposals are solicited from all relevant organizational units and those judged to have the greatest merit and priority are funded. Major needs may result in the approval and support of multiple projects to encourage and foster intra-company technical competition.

The review and approval of major product or engineering development proposals generally involve high level staff committees which include representatives of both domestic and international automotive operations.

Frequent internal technical seminars, conferences and training sessions will involve the bringing together (generally at a U.S. headquarters location) of engineers and planners from all parts of the organization. Presentations and status reports on technical developments and needs in various parts of the world will be made.

All of the oversees organizations have technical and engineering liaison personnel representing the parent company to facilitate information exchange and joint problem solving.

The personnel organization of the larger companies (and possibly all) have detailed computerized records of the technical skills and areas of experience and expertise of all employees such that a search of such records to identify special needs can be readily made. In addition, there are important informal networks to quickly identify who knows what.

With the increasing importance of international operations, a standard practice is to rotate promising managers and executives through key positions in foreign subsidiaries as an integral part of their development. Such exposure is regarded as important to the assumption of high level positions in the corporate management.

The assignment of engineers and scientists to temporary overseas posts (including that of foreign nationals to U.S. posts) and the formation of special task groups dealing with multinational projects provide means for both information exchange for specific purposes as well as for effecting transfers of technology between organizational units (or perhaps more properly - for increasing the rate of technological development in different parts of the multinational organization).

Though mechanisms exist for the transfer of technology, our impression is that transfers of technology per se are not a direct or primary concern from the viewpoint of the automobile manufacturers and their internal operations, except perhaps in relation to the protection of proprietary products and processes. Transfers are made to effect cost reductions, solve special product or production problems and, in general, to enhance the company's competitive position in the markets being served. Transactions with independent firms, suppliers and affiliated companies, however, are formal or contractural and, since they normally involve an exchange of money, they require an explicit valuation of expected future return from the transactions versus the costs or returns from alternative endeavors. Where such transactions involve parties in foreign countries, the added ingredient of the legal and political environments of the respective

countries, must be given consideration, including, for example, the stability and security of capital investments, limitations on royalties, local content restrictions, tariff and other import-export constraints and a host of other factors (economic and noneconomic) that serve to qualify each environment in special ways. While it was well beyond the scope of the present study to attempt any country-by-country assessment of such factors, it may be noted in general that the closer the political, legal, and economic environments of the host country approximate that of the U.S. the more likely that the U.S. automobile manufacturers will have significant investments and exchanges of technology - formal and otherwise.

An important corollary proposition should be added to the above observation. The more that market needs and other conditions between two or more foreign countries are similar, the more likely direct transactions and technology transfers seem to occur between subsidiary or affiliated companies in those countries. Such transactions may form the basis for exchanges and technology flows to the U.S. market. Cases in point include, for example, Ford's efforts in the late '60's to force greater integration and product rationalization between its English and German subsidiaries and G.M.'s more recent cooperative programs between its German and Brazilian subsidiaries which led eventually to the U.S. produced Chevette. The general movement in evidence is for more and more extensive interchanges of this type and for a higher degree of complementation or multinational sourcing.

A natural by-product of this movement into complementation is the emergence of both a higher degree of specialization

(and concentration) of manufacturing, engineering and related technology developments in certain countries and a higher degree of uniformity and standardization in products and technology across countries. There are, of course, practical limits to the extent to which this process can be carried without incurring an excessive risk of becoming hostage to interruptions in vital elements of supply. The force of economic nationalism, at home and abroad, furthermore, acts as an effective brake to over-specialization or concentration in sourcing.

Nevertheless, the largest multinational companies, whether U.S. based or foreign based, have the greatest opportunity to benefit from realizable economies of scale and from multiple sourcing -- in all aspects of the business including technological innovations.

3. TECHNOLOGY TRANSFERS BY U.S. AUTOMOBILE MANUFACTURERS

The following account of technology transfers by each of the U.S. automobile manufacturers is very preliminary and sketchy at best. Most respondents when asked to identify significant technology transfers were hard pressed to think of any, could not (or would not) be very specific, and generally mentioned items related to fuel economy. They also tended to think or respond in terms of licensing or other formal agreements with outside firms rather than in relation to internal flows. A number of possible explanations come to mind:

Concern about internal security precluded an open discussion.

We talked to the wrong people.

There are in fact very few significant internal transfers of technology.

The discussion was biased by the present high level of concern for fuel economy improvement.

The most significant transfers are in fact related to fuel economy.

The visibility and formality of licensing and other formal agreements biases perception in their favor.

The preponderance of automotive technology is common currency such that it is a matter of relative indifference where a particular development takes place.

Whatever the explanation, the following presents the gleanings from direct discussions with managers of the

four principal U.S. automobile manufacturers.

3.1 GENERAL MOTORS CORPORATION

Only two items were volunteered by G.M. concerning significant flows to the U.S. during the last five years:

a) Technology relating to their downsizing of U.S. cars from Adam Opel in Germany and Vauxhall in England. The primary example is the current Chevette which is an Opel derivative that came to the U.S. via Brazil. The immediate predecessor was the Brazilian Chevette introduced in 1973 and justified in terms of the South American market, apparently without reference to or any planned introduction in the U.S. market.

b) Technology related to passenger car diesels from Opel in Germany. There were no details forthcoming, and we assume that Opel engineering or engineers played a significant part in Oldsmobile's modification of a standard I.C.E. to diesel operation and now sold as an optional engine on certain Oldsmobiles, Chevrolet and G.M.C. light trucks, and the Cadillac Seville.

Within G.M.'s international operations, important transfers appear to have occurred for both product and production technology from Opel and Vauxhall to operations in Braxil, Argentina, South Africa and Australia, as well as to other parts of G.M.'s far flung operations.

3.2 FORD MOTOR COMPANY

Discussions with Ford identified the following as significant technology flows:

a) The use in the U.S. of plastics technology developed by its European subsidiaries. No details or specifics were provided.

b) Ford's acquisition of float glass technology from Pilkington in England.

c) Ford's licensing agreements with N.V. Philips of Holland and United Stirling in Sweden for stirling engine technology and further development work.

d) A technical information exchange agreement with Honda of Japan concerning CVCC engine developments.

e) A license with Curtiss-Wright (U.S. and NSU of Germany for rights to Wankel engine technology.

Under our definition the last three are all potential technology transfers with the last item no longer being actively pursued at Ford. Also, only the first represents an internal transfer from Ford's foreign subsidiaries.

The most significant aspect of Ford's multinational technology development is represented by a deliberate effort to increase complementation, a move in which Ford has taken a leadership position. The concept of complementation was characterized by Henry Ford II, in the following terms: "To those of us at Ford, it is a fancy word for interregional free trade in motor vehicles and components."[1] We quote at some length from the cited Ford publication:[2]

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[1]David L. Lewis, Ford: A Global Corporation, Ford Motor Company, Dearborn, MI, 1973, p. 10.

[2]Ibid, p. 10.

> Ford's initial experience with complementation came in the early 1960's, when manufacturing responsibility for its tractor line was divided among three subsidiaries. Ford of England assumed responsibility for producing engines and hydraulic systems; Ford Tractor in Belgium, rear axles and 4- and 8-speed transmissions; and Ford U.S., 10-speed transmissions. Through complementation, the company avoided duplication of tooling costs, maximized product quality by limiting the number of industrial processes for which each Ford affiliate was responsible, and achieved lower per unit costs through higher volume production.
>
> The Capri, introduced in Europe in 1969, and in America in 1970, represents a significant advance in the complementation concept. Ford of Britain and Ford of Germany jointly designed the Capri, then went on to supply specialized engines and transmissions for the car. Europewide acceptance of the Capri confirmed the Company's hope that regional products might supplement, if not altogether supplant, nationally produced vehicles.

Currently, Ford is moving to increase the extent of complementation in other regional markets, notably the Asia-Pacific region and later the Africa-Middle East region as that market develops further. Inherent to the implementation of complementation is not only the free flow of goods (vehicles as well as components) but also the free flow of technology.

3.3 CHRYSLER CORPORATION

Chrysler was unwilling to volunteer any specific information concerning technology transfers. It was acknowledged that Chrysler's Huntsville electronics facility was doing R&D work for its European subsidiaries. There is little doubt, however, that Chrysler, like Ford and GM, includes senior managers from its European subsidiaries in high-level domestic policy and planning committees and is pursuing a

course of increased multinational cooperation in product and developmental planning.

The recently introduced Omni and Horizon models are clearly derivatives of a successful Simca (Chrysler France) model line. The fact that the Omni and Horizon currently use engines and transaxles supplied by Volkswagen is a reflection of present capacity constraints in France, while VW had available excess capacity, and not any indication of a Chrysler need to rely on VW for its technology.

While Chrysler has been importing and marketing in the U.S. several car models engineered and produced by Mitsubishi, its affiliate in Japan, these models have been jointly planned for the U.S. market. Chrysler, nevertheless, maintains a relatively low profile in its relationships with the Japanese. Both companies have had mutual training and technical exchange visits, and it appears that Chrysler would like to strengthen its formal ties and cooperative exchanges with Mitsubishi. Evidence exists, on the other hand, that Mitsubishi would like to gain recognition in the U.S. market in its own right and include more direct identification with the products now sold through Chrysler.

3.4 AMERICAN MOTORS CORPORATION

No direct evidence exists of technology transfers between AMC and its overseas subsidiaries and affiliates who produce or assemble and market Jeeps. AMC, however, is highly dependent upon its suppliers, principally GM, for major aspects of its technology.

In 1975, AMC negotiated a contract with VW to acquire both 4-cylinder engines and an entire engine assembly

line designed by VW. Recently, however, AMC announced[1] that it was terminating its contract with VW and would purchase small engines from GM. There has been an even more recent flurry of speculation in the press sparked by AMC's announcement of its intent to complete in the near future some form of "arrangement" with a foreign automobile manufacturer. Whatever the arrangement or affiliation, one important element (in addition to AMC's obvious need for cash) is almost certainly to involve substantial infusion of foreign technology.

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[1] "AMC Will Buy Small Engines from GM by '80," Wall Street Journal, January 19, 1978.

4. FUTURE TRENDS AND DEVELOPMENTS

The present Chapter examines some of the implications and possible future directions and conditions of technology flows of the U.S. multinational automobile manufacturers. In view of the very scant data, the following account is rather speculative and probably oversimplified.

Virtually the entire period up to the mid-60's is characterized by two major features.

First, the U.S. companies were primarily exporters of manufacturing technology centered on the technology of mass production and automation. The period until the early 30's, however, was mainly one of exporting U.S. products and the building of assembly and manufacturing facilities abroad. The opening of Ford's major manufacturing complex in Dagenham, England in 1932 was probably the first such modeled along U.S. production lines.

The second characteristic of the pre-1965 period was that of a relatively slow, evolutionary process of product refinement and improvement paced by the rate of consumer acceptance and market development. The diffusion of automotive technology was widespread but relatively slow. The typical time periods from first successful introduction of new innovations to 50 per cent market penetration was from 10 to 20 years, including such innovations as disc brakes, power brakes and power steering, automatic transmissions, wide-bore-short-stroke high compression engines, air-conditioning

and many others. Other innovations such as high-energy ignition, fuel injection, diesel engines have not yet reached 50 per cent penetration in passenger automobiles.

Beginning in the mid-60's, two events have primed the U.S. industry for potentially significant changes.

First, under safety regulations and later emissions regulations, the industry entered a period of forced technological change through direct government intervention and across-the-board mandating of difficult minimum standards. This period, continuing to the present, was a time for the U.S. manufacturers of intense preoccupation with domestic problems which were caused by the need to comply with government standards.

Second, during the same period, the U.S. producers began to rationalize production operations abroad. These programs, led initially by Ford, have resulted in the regional complementation of car design, engineering, and production in Europe.

As we approach the 1980's, the U.S. automobile industry may now be in the early stages of most profound and sweeping changes. Again, two major ingredients (or forces) are working and interacting on a worldwide basis. The first factor is the pervasive concern with fuel economy and what is a real, serious, and lasting world problem of energy supply, distribution and utilization. The second factor involves a gradual erosion of significant differences in automobile needs and requirements in different national markets - the move toward what is generally referred to as the World Car.

Serious conflicts occur as in all large scale movements and changes, which make the forecasting of specific developments precarious at best. Despite these hazards, the major features of the emerging world automotive scene appear to us to include the following:

4.1 POLITICAL AND ECONOMIC CLIMATE

Governments will continue to exercise dominant and controlling influence over ever increasing aspects of the motor vehicle industry and the use and characteristics of motor vehicles. Strong pressures will arise for increased standardization and uniformity in requirements, but a reluctance will also exist on the part of other national governments to "dance to the tune" of the U.S. government. There will continue, into the unforeseeable future, strong economic nationalism and various economic and noneconomic barriers to the free flow of motor vehicle trade. Such economic nationalism will frustrate and constrain in various ways the automobile manufacturers' efforts toward increased complementation and multinational sourcing on a purely economic basis. Accomodations will nevertheless take place, and the move toward World Cars, while probably slow, will result from the development of genuine regional markets, a general lessening of significant product differentiation, and a convergence in automotive requirements, technology, materials and manufacturing processes. Cars will get smaller, more fuel efficient, and more alike.

National balances of trade, interregional or international trade deficits and surpluses will continue to be serious and vexing problems. While motor vehicle trade <u>per se</u> may be a small part of the problem, petroleum fuels and energy accounts are likely to be a large part of the problem.

The result will be the emergence of strong pressures for various corrective measures, protectionism, reprisals (not excluding military interventions), and new monetary or other instrumentalities for coping with serious monetary drains and imbalances.

4.2 CORPORATE STRATEGY AND ORGANIZATION

The larger motor vehicle multinationals, whether U.S. or foreign based, will have undeniable competitive advantages due not only to their size, but the multinationality of their engineering, production and marketing resources. AMC's survival in the passenger car business probably hinges on its becoming an effective multinational, through a merger with a strong foreign automobile manufacturer. There will almost certainly be additional mergers, consolidations and formal affiliations (or business failures) among existing automobile manufacturers and across national boundaries. Additional nationalizations or other forms of formal government participation in the ownership, control or subsidy of motor vehicle companies are also likely to occur.

The U.S. multinationals, as well as foreign-based MNC's, will pursue a course of increased complementation (preferably, complementation with a capital "C") in efforts to realize economies of scale on a multinational basis. To the extent they are able to do so, increased specialization and concentration in manufacturing and engineering support facilities will provide lower costs which in turn will allow lower prices and greater attending market shares on a worldwide basis.

4.3 TECHNOLOGY DEVELOPMENTS

Economies of scale exist in modern science and technology as in virtually everything else. The immediate

prospect for the U.S. motor vehicle manufacturers is a continuing concentration of major research and advanced development facilities and resources in the U.S. in close proximity to their national (and world) headquarters. However, other development and engineering resources will be concentrated in other major manufacturing centers and important regional markets. Component and subsystem engineering, product development, and manufacturing engineering are likely to become more specialized and concentrated in multiple centers strategically placed in several parts of the world. While technologically specialized, some degree of redundancy will and must exist in sources of supply as insurance against interruptions in the flow of needed materials and vehicle components, whether from political or other causes. The key point, however, is that increased technological concentration and specialization will probably lead to greater technological output which will be available for transfer across national borders.

Consequently, the dual pressures of fuel economy improvement and worldwide complementation signal a period of both accelerated technological development and rapid diffusion of such developments. We anticipate increased flows of technology in all directions - to and from the U.S. and between and among other regional markets. The strong support of the U.S. auto manufacturers for metrification is merely another signal in this direction. The prospect of increased federal government investment in advanced technology developments - in synthetic fuels and advanced power systems and components - further signals less exclusivity in automotive technology and possibly more rapid diffusion.

As cars get smaller and more alike in functional characteristics, we believe they will tend to become more uniform in their embodied technology. Increased use of front-wheel drives, plastics and lightweight structural materials are clearly in the offing; radical changes in engines and drive trains are also likely but on a longer time frame.

A period of rapid technological change, however, also means for the automobile industry - which is a highly capital-intensive industry - a need for large capital investments and accelerated write-offs and obsolescence of existing capital facilities. Substantial cost pressures will be reflected in higher product prices and the consequent lowering of industry volumes. The pacing of such changes will require a sensitive and careful balancing, by each of the companies, of imperatives at home against opportunities abroad.

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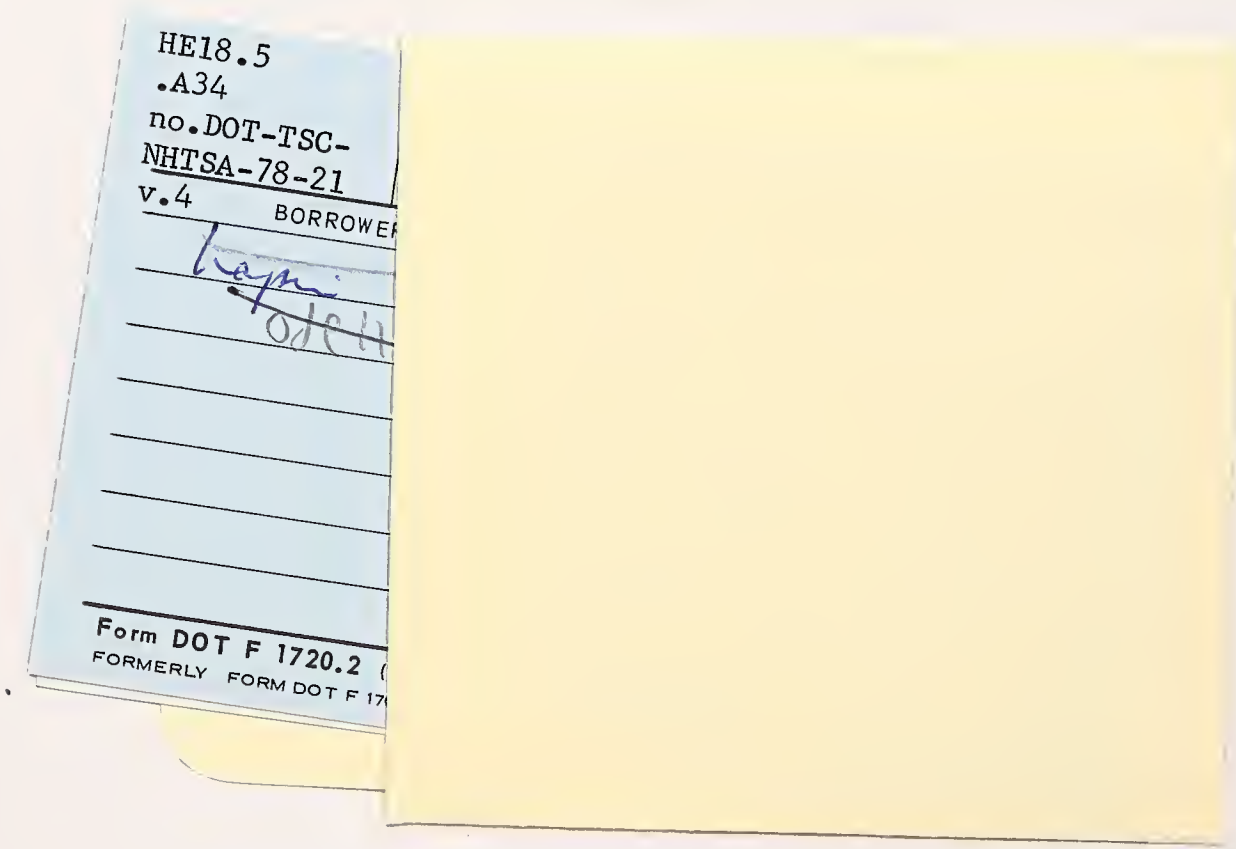
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PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
U.S. DEPARTMENT OF TRANSPORTATION
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